Human Systems Roadmap Review

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Systems Interfaces and Cognitive Processes
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Human Aspects of Operations in Military Environments
Dr. Liz Bowman (Army)
Dr. David Scribner (Army)
Dr. Rebecca Goolsby (Navy)
Mr. Eric Hansen (AF)

Human Systems Community of Interest Vision and Goals

Vision:

Develop and deliver new human-centered technologies to quantify mission effectiveness and to select, train, design, protect, and operate for measurably improved mission effectiveness.

Goals – to enhance mission effectiveness

- **Integrated simulations for mission training and experimentation**
- **Human-machine designs for mission effectiveness**
- **Assessment of (candidate) operator effectiveness**
- **Operating through battlespace stresses**
- **Mastering the PMESII* battle space**

**Political, Military, Economic, Social, Infrastructure, & Information*

Human Systems Community of Interest Sub-Area Thrusts

Personalized Assessment, Education, and Training

Right Person, Right Job, Right Skills

- First Principles for Training Design
- Personnel Selection and Assignment

System Interfaces and Cognitive Processes

Effective, Natural Human-Machine Teaming

- Human-Machine Teaming
- Intelligent, Adaptive Aiding

Protection, Sustainment, and Warfighter Performance

Ensuring Warfighter Safety and Survivability

- Understanding and Quantifying the Effects of Critical Stressors
- Critical Stressor Mitigation Strategies

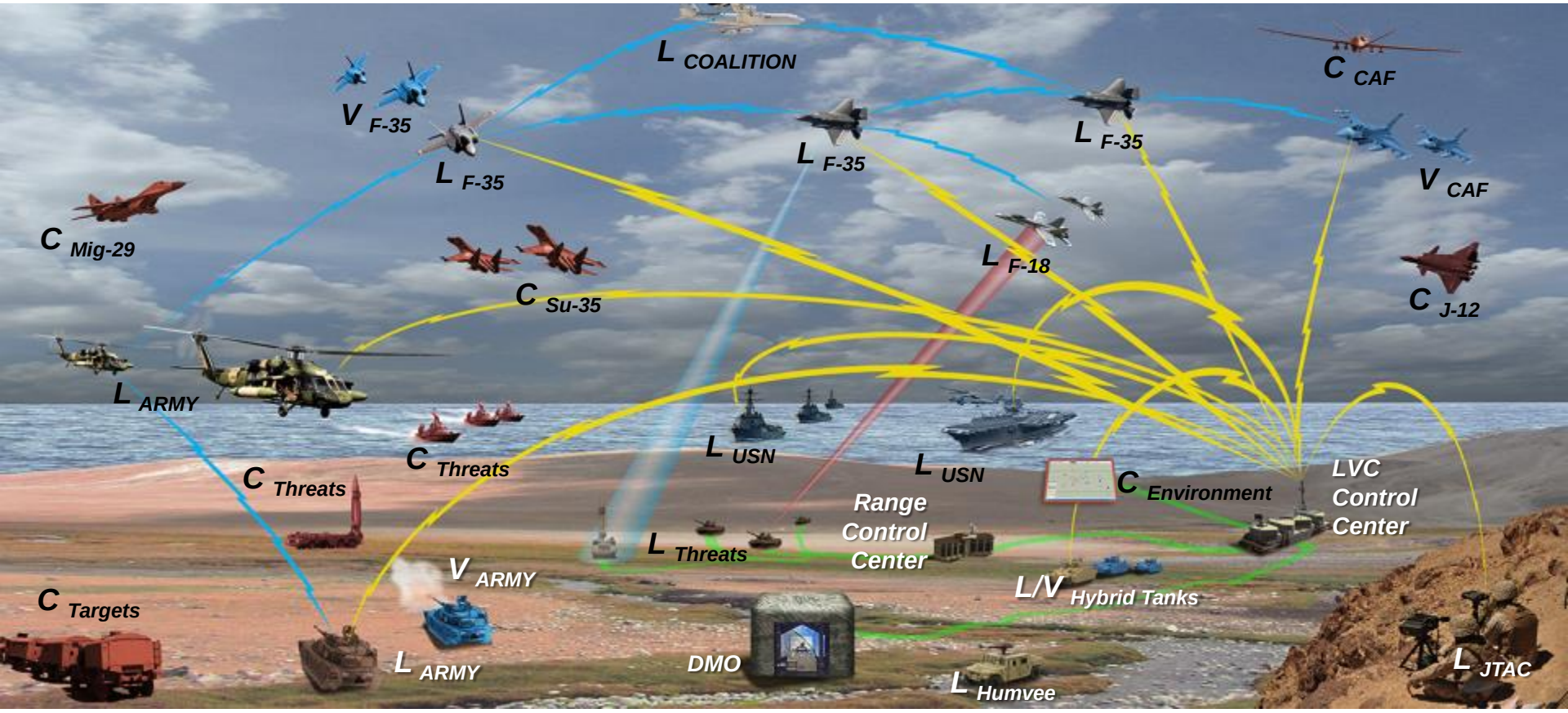
Human Aspects of Operations in Military Environments

Our Forces Prepared for Global Challenges

- Exploiting Social Data, Dominating Human Terrain, Effective Engagement

Operational Concept
Mission Effectiveness Quantification

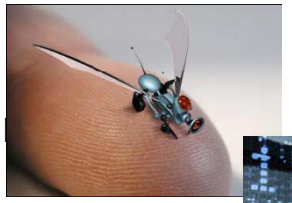
Capability: Integrated, persistent Live-Virtual-Constructive (LVC) training environments incorporating adaptive training methods to accelerate Service, Joint, and Coalition Readiness



Affordable Mission Realism – Integrated Forces – Quantified Effectiveness

Ideas: Third Offset
Five building blocks

- **Autonomous Learning Systems**
  - Delegating decisions to machines in applications that requi faster-than-human reaction times
- **Human-Machine Collaborative Decision Making**
  - Exploiting the advantages of both humans and machines for better and faster human decisions
- **Assisted Human Operations**
  - Helping humans perform better in combat
- **Advanced Manned-Unmanned System Operations**
  - Employing innovative cooperative operations between manned and unmanned platforms
- **Network-enable, autonomous weapons hardened to operate in a future Cyber/EW Environment**
  - Allowing for cooperative weapon concepts in communications-denied environments



Department of Defense's Third Offset
Human-Machine Collaboration; Combat Teaming

Human Systems COI S&T Focus Areas that Address the Five 3rd Offset Elements

1. **Learning Machines**
   - Computational Models of Human Cognitive, Psychomotor, and Perceptual Capabilities
2. **Human-Machine Collaboration**
   - Intuitive, Multi-sensory, Adaptive Interfaces
   - Natural Language Interfaces
3. **Assisted Human Operations**
   - Intelligent, Adaptive Aiding
4. **Human-Machine Combat Teaming**
   - Trust Calibration and Transparency of System Autonomy
   - Metrics of Mission Effectiveness at Individual and Unit Level
5. **Autonomous Weapons**
   - Systems that can take action, when needed
   - Architectures for Autonomous Agents and Synthetic Teammates

… and Experiments Using Realistic Mission Scenarios

Service Demand Signals

Personalized Assessment, Education and Training

- Personalized, integrated assessments and training to improve performance, accelerate proficiency and increase affordability
- Enhanced warfighter performance through scenario based training & automated performance based readiness assessments
- Maintain air superiority over complex, evolving threats using adaptive training

System Interfaces and Cognitive Processing

- Achieve operational maneuverability through soldier-system integration
- Design systems to enable effective human machine interaction, including robotics & autonomous systems
- Enhanced interaction & trust w/autonomous systems; increased SA for operators; reduced analyst workload

Protection, Sustainment and Warfighter Performance

- Greater force protection to ensure survivability across all operations and environments
- Maintain health & injury recovery; reduce noise induced hearing loss
- Agile Combat Support through countering aerospace physiology and toxicology threats, reducing cognitive workload

Human Aspects of Operations in Military Environments

- Provide situational awareness; timely mission command and tactical intelligence human-agent teaming

- *Army Enduring Challenges*
- *Navy Vision/Objectives*
- *AF Core Mission/Challenges*

Outreach Highlights

Federal, Industry and Academic Outreach

- Annual NDIA Human Systems Conferences
- Biannual Industry Research & Development Technology Interchanges
- Strong leverage of basic science research
- NASA participation in HS COI
- Cross Agency participation in National Science and Technology Council Network and Information Technology Subcommittees

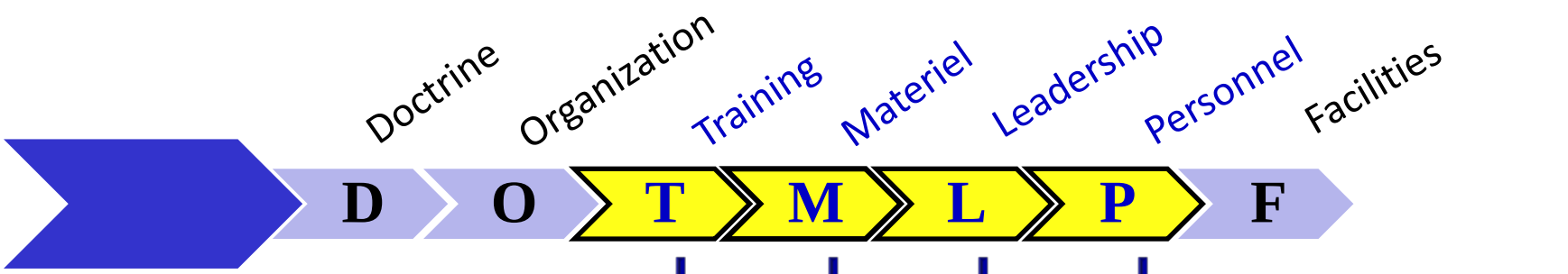
International Engagement

- Singapore: HS COI workshop leading to MINDEF/DoD Human Systems roadmap
- India: HS COI Cognitive Sciences workshop led to multiple Project Agreements currently in negotiation
- Japan: February 2016 Team Visit to explore Trusted Human-Autonomy Teaming
- NATO: Leading strategically targeted activities in Science and Technology Organization Panels: Human Factors and Medicine, Info Systems, SAS
- TTCP: Strong Participation in Human Performance, C3I Groups
  - Restructured HUM to focus on transition opportunities
  - Leading the first TTCP Cross-Group Panels on Human Systems Land and Air

COI-to-COI Collaborations

- **ASBREM**
  - Human Performance Optimization Committee
  - Joint Biomedical Modeling and Simulation Initiative
  - Walter Reed Army Institute of Research (WRAIR) evaluating TAPAS as a contributor toward predictors of mental health & medical attrition
- **ASBREM, Sensors, CWMD**
  - Wearable Physiological Monitors
- **Autonomy**
  - Roadmap development: Human-Machine Teaming shared area
  - V&V Licensing Study
  - Executing Joint-Service Autonomy Research Pilot Initiatives
- **C4ISR**
  - Human-Computer Interaction (HCI) for Decision Making Subgroup - seedling proposal funded for 2 years in 2015 (Army, Navy, Air Force)
- **Cyber**
  - Cyber Selection and Training
  - Cyber Situational Awareness
- **CWMD**
  - Dark web concerns, social network analysis, and counter-terrorism research

Impact of Human Systems Community of Interest



$450M COI Budget Has Broad Impact in Several DOTMLPF Areas

Defense Innovation Marketplace

- **For Industry, the Defense Innovation Marketplace is:**
  - A place to learn about DoD R&E investment priorities and technology requirements.
  - A source allowing industry to align their IR&D efforts to b support the current and future needs of the warfighter.
  - A link to specific solicitations, upcoming R&E related eve Communities of Interest, and Technology Interchange Meetings; ***improving visibility to DoD activities***.
  - A portal to securely share their IR&D projects with S&T/R and acquisition personnel they consider their target mark

- **For DoD, the Marketplace is designed to be:**
  - The place to post important, relevant and future needs, S&T/R&E priorities, events, presentation and solicitations.
  - A secure portal for registered and approved DoD S&T/R&D and acquisition personnel to gain ***insight and visibility into industry IR&D investments.***

SUB-AREA S&T THRUSTS

Personalized Assessment, Education, and Training

HUMAN SYSTEMS COI SUB-AREA:
Personalized Assessment, Education, and Training

VISION

Measure and train for joint mission effectiveness.

TRAINING: Accelerate Individual Proficiency and Joint Force Readiness

Past: Skills for specific tasks/missions; slow update; same training for all	**Near → Future**: Competency-based for full spectrum; rapid updates; adaptive training accelerates learning

(Live + Virtual + Constructive) + Adaptive Training → ***• Integrated*** ***• Personalized***

PERSONNEL: Optimize Person-Service-Job Match

Past: Separate measures; same test for all; group probabilities of potential	**Near → Future**: Integrated measures & adaptive testing for more precise assessment of individual potential

(Cognitive + Non-cognitive + Physical) + Adaptive Testing → ***• Integrated*** ***• Personalized***

Thrust 1: First Principles for Training Design

Delivering the Mission

Ensuring measurable mission effectiveness

- Competency-based training will enable adaptive personalized learning that ensures mission effectiveness
- On-demand realistic training will increase warfighter agility
- LVC enables delivering this training beyond the individual to teams
- Reduction in training development and delivery costs can deliver more frequent tailored training

Delivering Capability

Develop training technologies for large scale Live, Virtual and Constructive (LVC)

- Better models enable building more realistic synthetic agents to play blue or red forces

Deliver life long learning

- Continuous career field learning and management and persistent measurement

Key Technical Challenges

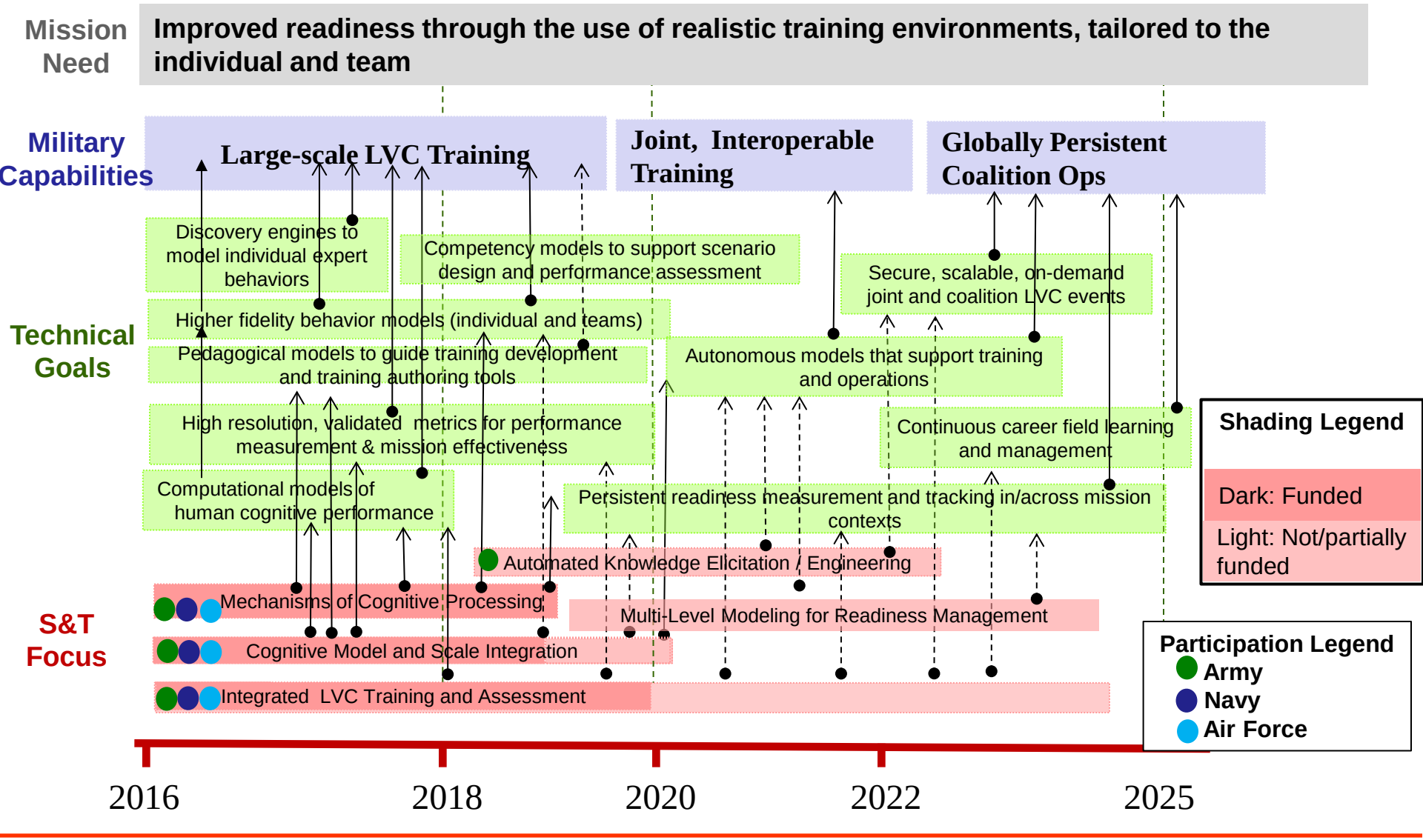
Develop ability to model individual expert behaviors

- Need pedagogical models/knowledge elicitation for training development (e.g., intelligent tutoring systems (ITS)).
- Need to validate high resolution metrics to measure mission effectiveness at individual and unit level.
- Need computational models of human cognitive, psychomotor, and perceptual capabilities for current and future missions

Program Overview

- ❑ Adaptive Training Research
- ❑ Joint and Coalition Training Research
- ❑ Augmented Reality for Training Research

First Principles for Training Design



First Principles for Training Design
Program Detail

S&T Focus Areas	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Integrated LVC Training and Assessment *Develop, validate, demonstrate and establish processes, procedures, and environments to seamlessly integrate responsive training and assessment into Live, Virtual, and Constructive (LVC) operations across the Range Of Military Operations (ROMO)*	Adaptive LVC Training for Enhanced Warfighter Readiness						Seamless integration of live, virtual, & constructive training environments; personalized training grounded in operationally relevant proficiency assessments; Range infrastructure to support LVC integration for 4th/5th gen aircraft; scalable, adaptive constructive agents that think and act like people to support training & ops
	Adaptive Training for C4ISR						
		Secure LVC Advance Training Environment.					
	Autonomous Models and Agents for Training & Operations						
	Live Virtual Constructive Simulation & Training						
	Live, Virtual, Constructive Training Fidelity						
Cognitive Model and Scale Integration *Bridge the gap between high fidelity simulations of human cognition in laboratory tasks and complex, dynamic environments; Reduced development time/cost while increasing model complexity, adaptivity, and fidelity*	Autonomous Models and Agents for Training & Operations						Decreased costs and increased reusability of constructive agents for training; Trainable agents for personalized learning that keeps pace with ops tempo; Improved integration and interoperability with operational training systems
	Adaptive LVC Training for Enhanced Warfighter Readiness						
	Adaptive Training Research						
	Computational/Cognitive Models for ITS						
Mechanisms of Cognitive Processing *More robust, valid, & Integrated mechanisms that enable constructive agents that truly think and act like people*	Autonomous Models and Agents for Training & Operations						Increased adaptivity in constructive forces for training; Enhanced validity; increased cognitive & behavioral fidelity; agents that are language enabled & situationally aware
	Virtual Human Research						
	Biorobotic Computational/Cognitive Modeling						

Success Story: Joint Theater Attack Controller Training and Rehearsal System (JTAC TRS)

Operational Challenge

High fidelity simulation does not exist for Joint Terminal Attack Controllers

Problem: Lack of live air does not allow for training as usual, simulation required to supplement live training

Objective: Create validated high fidelity simulation environment that allows for transfer of training

Outcome: JTAC TRS training research results drove the requirements of the acquisition of the USAF operational training system over 32 systems to be fielded in US and Coalition locations

S&T Accomplishments

- First immersive environment to receive Joint Fires Executive Steering Committee accreditation for types 1, 2, and 3 daytime controls for training concurrency and deployment preparation (i.e., accredited to provide training for all US services and JTACs from 18 nations)
- JTAC TRS training research results drove the requirements of the acquisition of the USAF operational training system (over 32 systems to be fielded) and is the baseline for UK, Naval Strike and Air Warfare Center simulators; Deployed testbeds in New Zealand, Ft Benning, and USAFE

Return on Investment

Affordability: Supplement live training with simulator training, reduce live air requirements

Readiness: Experimentation results yielded significant increases in successful attacks, number of ground vehicles neutralized, and a decrease in time to complete mission

Warfighter feedback: “I’ve been that grunt that never had that air support, so I’ve been in situations where you’re getting shot at and you’re like, ‘This is it, I’m dying’. With this, we give hope” - -Matt Hruska, Simulator Operator, ANG 169th Air Support Operations Squadron

Thrust 2: Personnel Selection and Assignment

Delivering the Mission

- Initial Military Training attrition is ~10% ($1.7B cost/yr).
- IMT attrition could be reduced to ~ 8% (saving ~.34B/yr) if current S&T product (TAPAS) was implemented to assess personality. IMT attrition could be reduced to 6% (saving $.68B/yr) with FY22 S&T products.
- Reduce negative behaviors for enlisted by ~5%.
- Increase satisfaction, performance, and retention in critical specialties by ~15%.

Delivering Capability

Maintain our competitive edge in Human Capital (Force of Future).

- Reduce attrition and negative behaviors with more precise assessments of candidates for initial entry & job assignment.
- Improve performance and retention with an emphasis on critical specialties (e.g., cyber) through advancements in talent assessment.

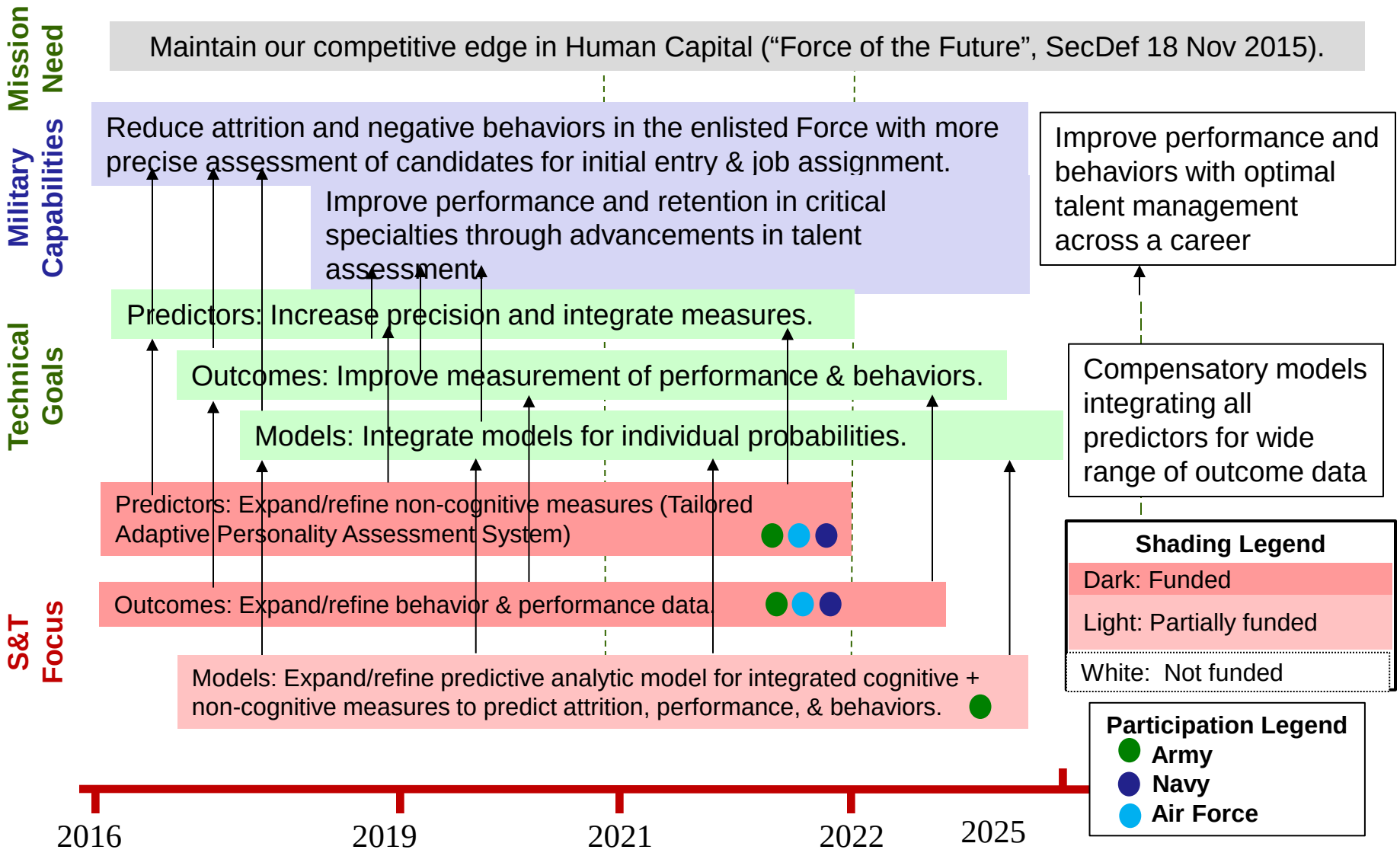
Key Technical Challenges

- Predictor measures: Existing measures lack individualized precision and are not integrated.
- Outcome measures: Performance and behaviors are difficult to measure and systematically obtain over a career.
- Predictive models: Existing models are stove-piped and based on group probabilities.

Program Overview

- **Develop and refine specialized cognitive tests**
- **Leverage Training S&T competency assessments in realistic mission scenario**
- **Predictive analytical models based on predictors and longitudinal outcomes**

Personnel Selection and Assignment



Personnel Selection and Assignment
Program Detail

S&T Focus Areas	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Predictors *Expand and refine non-cognitive measures (temperament, interests) and specialized cognitive assessments.*	Expand and increase precision of Tailored Adaptive Personality Assessment Develop, refine, and validate Vocational Interest Inventories Develop and refine specialized cognitive tests (e.g., Cyber, Strategic Thinking)						More precisely and fully assess individual potential and risk.
Outcomes *Integrate the behavioral and competency data that define criterion job performance.*	*Leverage Training S&T competency assessments in realistic mission scenarios.* *Develop, refine, and validate behavioral outcome measures*						More accurately assess performance and behaviors.
Models *Expand and refine predictive analytic models for integrated personnel measures to predict attrition, performance, & behaviors.*	Predictive analytical models based on predictors and longitudinal outcomes.						With enhanced Talent Management, improve performance, reduce attrition and negative behaviors.

Success Story: Enlisted Personnel Selection
Tailored Adaptive Personality Assessment System

Operational Challenge

Increase precision of assessing individual potential, risk, and fit to a military career.

- 26 personality dimensions such as optimism, excitement seeking, and non-delinquency
- Applicant chooses from statement pairs generated on-the-fly based on responses

S&T Accomplishments

- State of the art personality assessment
- Developed in partnership with industry
- 2009: Limited operational screening (Army)
- 2010-2011: Administered to recruits (Navy)
- 2014: Began selection for 5 specialties (AF)
- 2015: Administered to recruits (Marines)

TAPAS

Which of these statements is most like you?

- I am not one to volunteer to be group leader, but would serve if asked.
- My life has had about an equal share of ups and downs.

(example statement pair)

Return on Investment*

Readiness

- Reduces attrition by 5%
- Reduces Initial Military Training re-starts by 3%
- Reduces conduct incidents by 5%

Affordability

(attrition cost – recruiting, training)

- Current implementation saves ~ $30M/year
- Expanded use can save ~ $50M/year

* Based on Army data for limited operational screening.

System Interfaces and Cognitive Processes

HUMAN SYSTEMS COI SUB-AREA:
System Interfaces & Cognitive Processes

VISION

Warfighters teamed with machines through cognitively engineered interfaces that are intuitive to use, learn with experience about their users, and thereby enhance rather than disrupt the warfighter's focus on accomplishing their primary mission

This will be achieved through:

1. Investigating science and technologies that facilitate intuitive and seamless human-machine teaming.
2. Developing the ability to provide intelligent and adaptive tools and aids that are sensitive to warfighter state and the operational environment.

Achieving this vision will enable:

1. Actively coordinated teams of multiple machines in concert with human teammates executing desired mission effects *(Force multiplier- more mission effects with fewer resources)*

2. Safe and effective human-machine systems successfully operating in complex, dynamic & contested environments *(Force protector-desired effects without risk to most valuable resources; the human)*

3. Enhanced warfighter effectiveness by using adaptive situational aids and tools for mission success *(Mission/Situation adaptive aids ensures mission success)*

4. Coupling of real-time, closed loop quantification of both the warfighter and the machine to achieve unprecedented mission success *(Adaptive tools and aids ensure human-machine team is ready for unpredictable contested environment)*

Thrust 1: Human-Machine Teaming

Delivering the Mission

- Increased capability with smaller force structure across air, land, sea, space, and cyber
  - 1 MQ-9 Operator controlling 7 simulated MQ-9s
  - Reduced ISR PED Cell Operators from 5 to 3
- USTRANSCOM Global Mission Scheduling System
  - Reduced logistics and personnel footprint ; reduced planned flying hours >2% saving $37M/yr
- Trusted synthetic teammates that provide recommendations for battlespace operations
  - Reduced manpower and training requirements
- Ability to operate safely in highly contested environments
  - Reduced exposure to personnel

Delivering Capability

Seamless human-machine interfaces enabling optimized weapon system and warfighter performance in all contested domains and mission environments:

- Demonstrate highly effective, agile human-machine teaming
- Create actively coordinated teams of multiple machines
- Ensure safe and effective systems in uncertain and dynamic environments

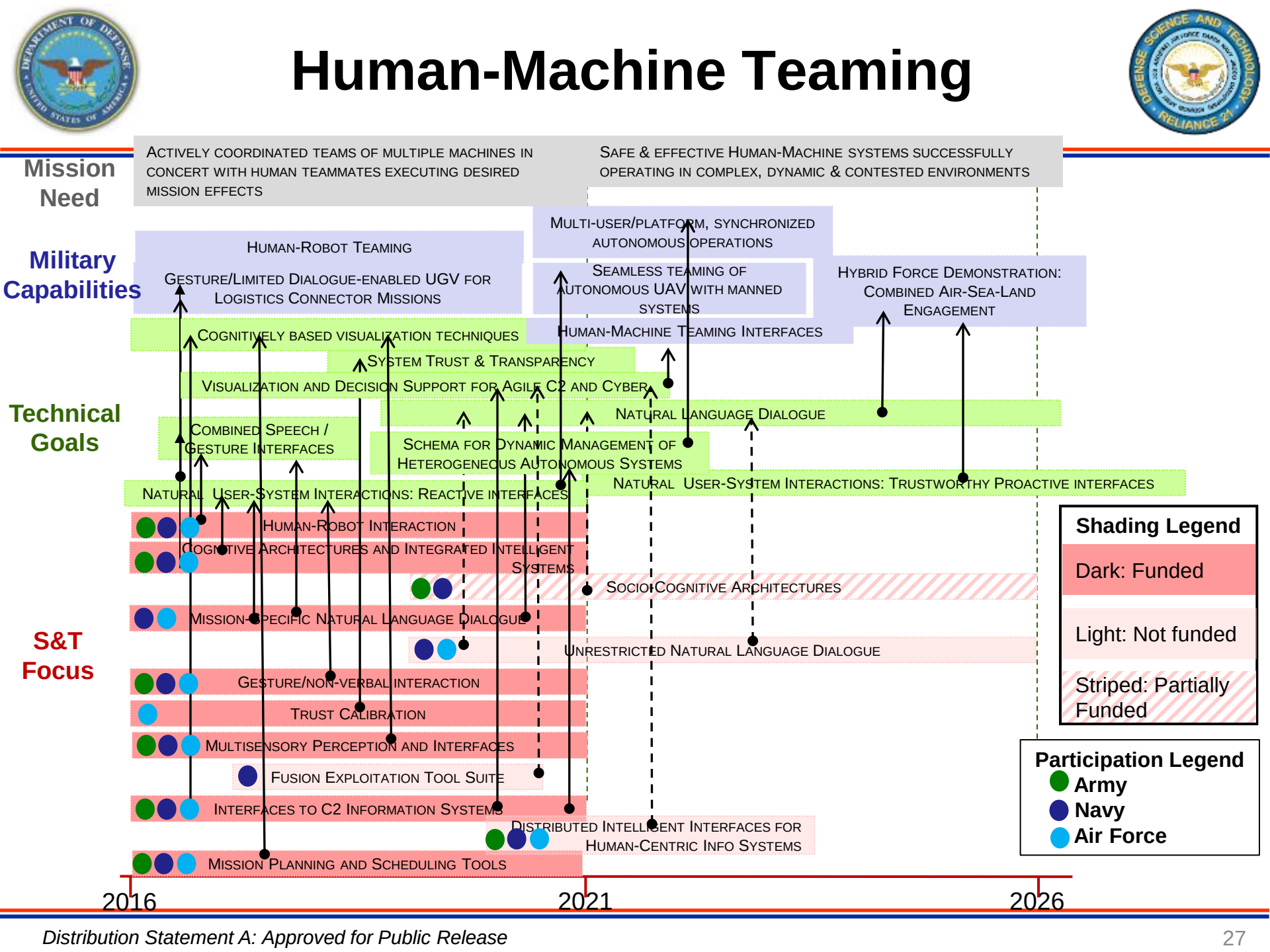
Key Technical Challenges

- Immature intuitive, multisensory, adaptive interfaces
- Lack of robust and reliable natural language interfaces
- Absence of effective gesture control interfaces
- Fragile cognitive models and architectures for autonomous agents and synthetic teammates
- Insufficient degree of trust calibration and transparency of system autonomy
- Immature decision support tools

Program Overview

- Cognitive Science and Artificial Intelligence
- Human Interaction with Adaptive Automation
- Human Insight and Trust
- Human Language Technology

Human-Machine Teaming



Human-Machine Teaming
Program Detail

S&T Focus Area	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Mission Planning and Scheduling Tools	Visual Interactive Exploratory Data Analysis						Mission planning and scheduling tools that simplify COA generation and enhance mission efficiency.
	Soldier-centered Design Tools						
	Mission Planning and Scheduling Tools						
Interfaces to C2 Information Systems	Supervisory Control Technology Integration and Demonstration						Operator-centered interfaces to C2 Information Systems that enhance/multiply mission effectiveness.
	Soldier-centered Design Tools						
	Interfaces to C2 Information Systems						
Multisensory Perception and Interfaces	Multisensory Perception and Data Presentation Interfaces						Novel multi-modal human-system interfaces that enhance operator performance.
	Soldier Sensory Performance						
	Advanced Technologies for Battlefield Airmen						
Cognitive Architectures and Integrated Intelligent Systems	Cognitive Architectures and Integrated Intelligent Systems						Cognitive architectures that maximize human-machine team performance.
	Perceptional and Cognitive Foundations of Soldier Performance						
	Brain-Computer Interaction						
	Human Insight and Trust						
Human-Robot Interaction	Human-Robot Interaction						Human-machine teams that can successfully operate in an agile fashion in an operational environment.
	Human-agent Teaming, & Shared Cognition						
	Human Interaction with Adaptive Automation						

Success Story: Autonomy Research Pilot Initiative: Realizing Autonomy via Intelligent Adaptive Hybrid Control

Operational Challenge

Autonomous control of multiple unmanned systems for military operations

Problem: Current fielded systems fall far short of desired advanced, highly reliable autonomous cooperative behavior

Objective: Increase the robustness and transparency of autonomous control for multiple unmanned systems

Outcome: Agile and robust mission effectiveness across a wide range of situations, and with the many ambiguities associated with the "fog of war"

S&T Accomplishments

- Intelligent Multi-UxV Planner with Adaptive Collaborative Control Technologies (IMPACT) architecture designed
- IMPACT "DoD Virtual Lab" established (Year 1)
  - 1 operator x 6 vehicles (simulation)
- Developed tri-service "Base Defense" challenge scenario
- IMPACT operational user assessment conducted
- Co-development of R&D testbeds at ARL and SPAWAR
- Year 2 Goal: 1 operator x 12 vehicles (simulation)
- To date, 23 S&T publications produced
- To date, 8 academia collaborations established

Return on Investment

Affordability

- Reduction in logistics footprint for equipment and personnel
- Risk Reduction: Opportunities to transition IMPACT technologies to other DoD programs

Readiness

- Force multiplier: Autonomous control of multiple weapon systems with fewer personnel

Success Story: Improve Airlift Mission Planning Efficiency Global Mission Scheduling (GMS)

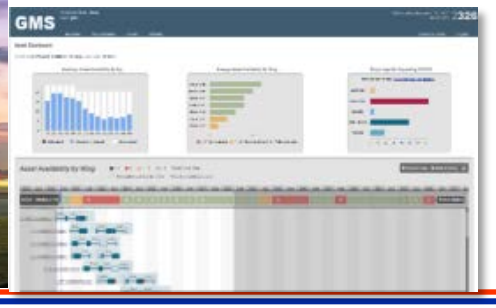
Operational Challenge

Support USTRANSCOM/AMC plan fuel efficient airlift

Problem: Current airlift mission planning tools are manual spreadsheet type tools causing inefficiencies to be unintentionally passed to execution (e.g. empty flights, underutilized cargo aircraft)

Objective: Improve airlift effectiveness through improved mission planning.

Outcome: Reduction in planned flying hours resulting in fuel cost savings.



S&T Accomplishments

- GMS Version 1 demonstrated in FY14
- GMS Version 1 delivered to AMC in FY15
- GMS Version 1 to be integrated into Consolidated Air Mobility Planning System in FY16
- GMS Version 2 plans to improve mission precision and fuel tradeoffs, and interoperability with USTRANSCOM planning systems
- GMS Version 2 funded through FY17 to demonstrate mission planning for Surfing Air Vortices for Energy Advance Technology Demonstration

Return on Investment

Affordability

- Reduction in flying hours and fuel costs
  - Estimated reduction in planned flying hours >2%
  - Estimated fuel savings of 70M lbs. of fuel or $37M/yr. based on FY15 JP8 fuel rates

Readiness

- Efficient use of C-5 and C-17 aircraft
  - Improve pairing of aircraft with cargo to ensure aircraft are fully utilized.

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Thrust 2: Intelligent, Adaptive Aiding

Delivering the Mission

- Maintain mission effectiveness despite fluctuating demands: No mission degradation in a high tempo environment
- Optimized human-machine teaming: Dynamic workload allocation to improve mission efficiency
- Provides shared situation awareness and transparency between the operator and the weapon system platform: Appropriate level of operator trust
- Optimized warfighter readiness and enhanced training: Identification of relevant biomarkers indicative of operator cognitive and physiological state

Delivering Capability

Enhance warfighter effectiveness by coupling humans and machines through the use of intelligent adaptive aids to protect from being overwhelmed by complexity and workload.

- Develop models of perception and cognition
- Assess the functional state of the operator
- Real-time measurement and assessment of warfighter performance

Key Technical Challenges

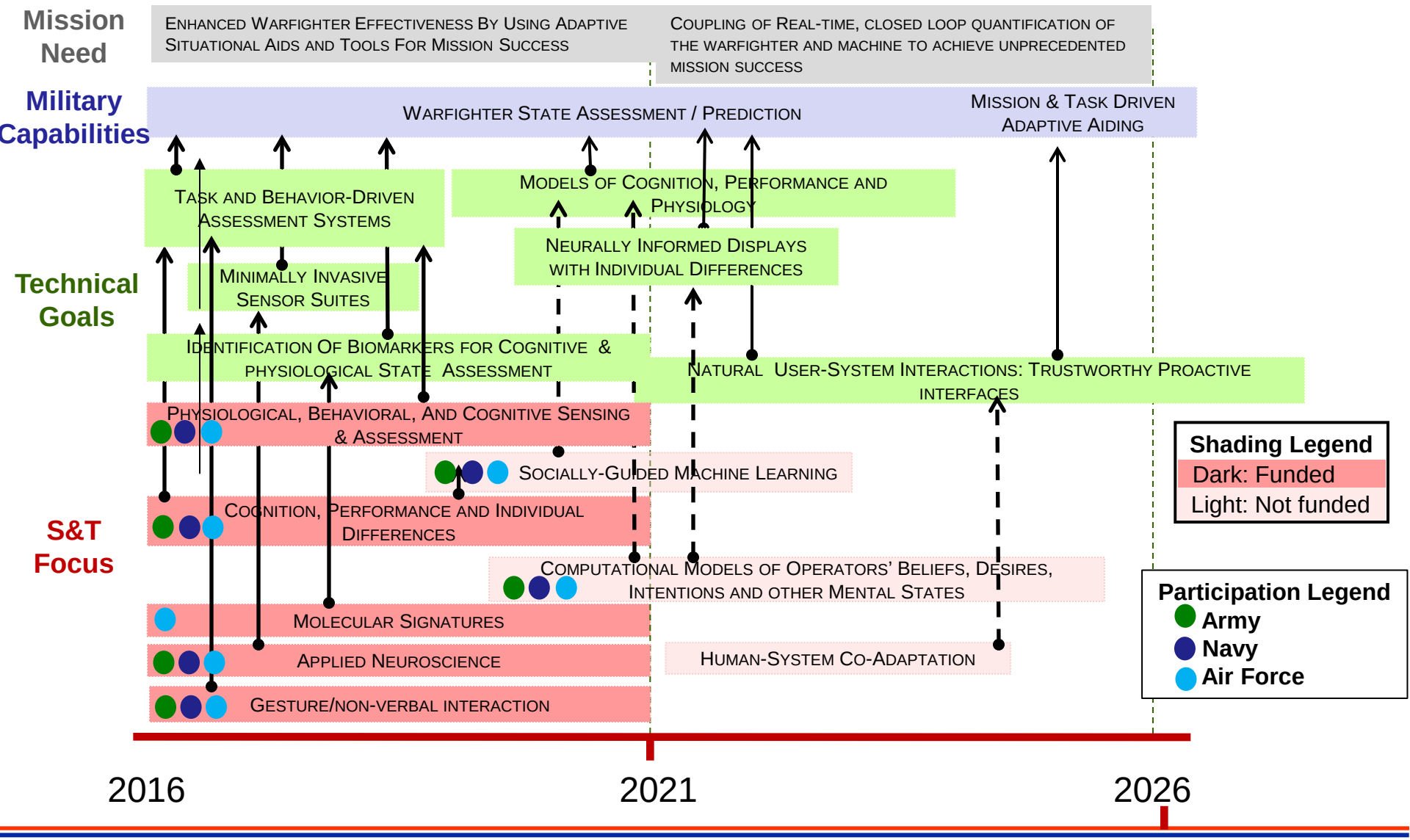
- Immature tools for individual and team functional state assessment
- Fragile cognitive models
- Operationalize minimally invasive sensor suites
- To Identify the appropriate biomarkers for determining operator performance
- Absence of effective gesture/non-verbal interfaces

Program Overview

- Applied Adaptive Aiding
- Molecular Signatures
- Perceptional & Cognitive Foundations of Soldier Performance
- Cognition, Performance, and Individual Differences

Distribution Statement A: Approved for Public Release

Intelligent, Adaptive Aiding



Intelligent, Adaptive Aiding
Program Detail

S&T Focus Area	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Gesture/Non-Verbal Interaction	Gesture and Non-verbal Interaction Brain-Computer Interaction Applied Adaptive Aiding						Human-machine interaction using gestures and/or other non-verbal means to communicate/execute mission intent.
Applied Neuroscience	Applied Computational Neuroscience Translational Neuroscience Molecular Signatures Soldier-focused Neuro-technologies						Real-time, omnipresent-sensing technology, signatures of brain networks that capture changes in task performance and brain-based technologies to aid the operator and optimize team performance.

Intelligent, Adaptive Aiding
Program Detail

S&T Focus Area	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Cognition, Performance, and Individual Differences	Cognition, Performance and Individual Differences Cognitive Performance Optimization Perceptional and Cognitive Foundations of Soldier Performance						Advanced technology to sense, measure and quantify individual warfighter cognition and performance parameters to predict and augment warfighter performance.
Physiological, Behavioral, and Cognitive Sensing and Assessment	Applied Computational Neuroscience Perceptional and Cognitive Foundations of Soldier Performance Soldier-focused Neuro-technologies Molecular Signatures Cognitive Performance Optimization Applied Adaptive Aiding						On-line operator monitoring and assessment technology, integrating multiple and concurrent data streams to predict and augment warfighter performance.

Success Story: Enhanced Battlefield Airmen Effectiveness
Advanced Technologies for Battlefield Airmen

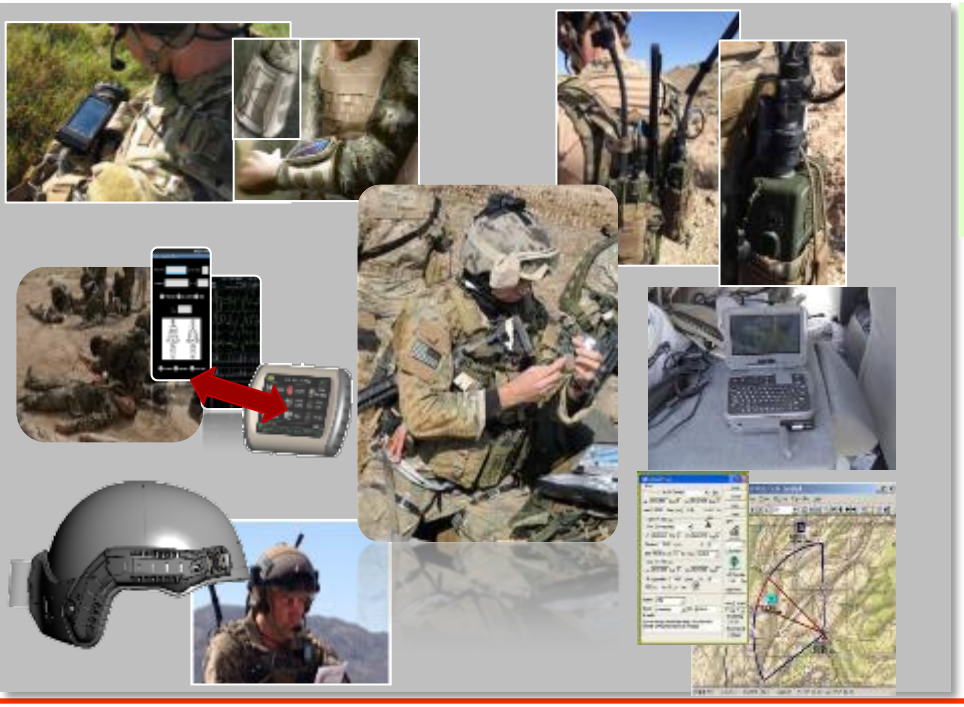
Operational Challenge

Improve survivability / lethality of Battlefield Airmen

Problem: Current equipment interfaces are not intuitive or ergonomically effective, requires intensive training and has resulted in fatal errors.

Objective: Address operational challenges faced by the Joint Terminal Attack Controller and Pararescue Jumper (PJ).

Outcome: Intuitive, airman-centered equipment/interfaces.



S&T Accomplishments

- 30+ technology transitions from 2004 – Present
- Reduced total weight carried by battlefield airman by 50%
- Optimized ergonomic fit of equipment to the operator
- Mass casualty health monitoring – 1 PJ for 5 patients

"This [BATDOK] increases our capabilities and effectiveness in a mass-casualty incident"
- Lt Col Stephen Rush, 106th Rescue Wing, Flight Surgeon

"Sirs, just got out of an after actions/lessons learned briefing from one of our ST guys that just returned from theater, SSgt Gutierrez. Wanted to pass on his praises of the MR-1 and PRC-152 specifically; he made multiple comments on how both of these pieces of gear made him more combat effective".
- Capt Joe Gross, 720th OSS

Return on Investment

Affordability

- Reduction in the number of pieces of equipment carried into the field

Readiness

- Increased lethality
- Increased survivability
- Decreased time to execute a mission

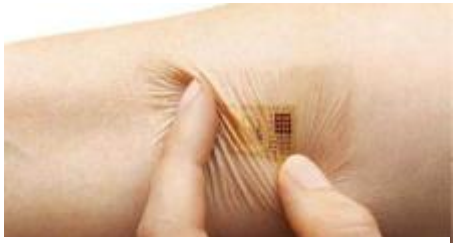
Protection, Sustainment, and Warfighter Performance

HUMAN SYSTEMS COI SUB-AREA:
Protection, Sustainment, and Warfighter Performance

VISION

Warfighters capable of fighting through stress to complete their mission while protected from threats in their environment.

DARPA Warrior Web early prototype



Wearable sensor technology

This will be achieved through:

1. Understanding the factors that influence individual performance
2. Developing the ability to measure performance in the operational environment
3. Developing strategies to mitigate the effects of critical stressors on performance

Achieving this vision will enable:

1. Warfighter protection aligned to mission specific threat, environment, and region allowing for optimal performance while maintaining protection
2. Increased ability to perform at a higher stress level without a performance decrement or increase in injury potential
3. The ability to measure performance in training and operational environments
4. New technology capable of measuring current Warfighter state and predicting current and near term performance, resulting in 20% increase in task performance
5. Load mitigation strategies resulting in 25% decrease in metabolic cost

Thrust 1: Understanding and Quantifying the Effects of Critical Stressors

Delivering the Mission

- Real-time data analysis and performance prediction will enable improved resilience by providing critical information on Soldier readiness.
- Understanding the underlying mechanisms through which critical stressors influence performance will enable greater performance.
- Understanding individual differences in the effect of critical stress on performance will enable greater Warfighter resilience.

Delivering Capability

- Developing technology capable of objectively measuring warfighter performance in operational environments will enable real-time monitoring of Warfighter performance.
- Understanding the underlying mechanisms through which performance is influenced will provide a pathway to optimizing Warfighter performance.
- Model individual responses to critical stressors will enable the leveraging of individual variability as a means of improving Warfighter performance.

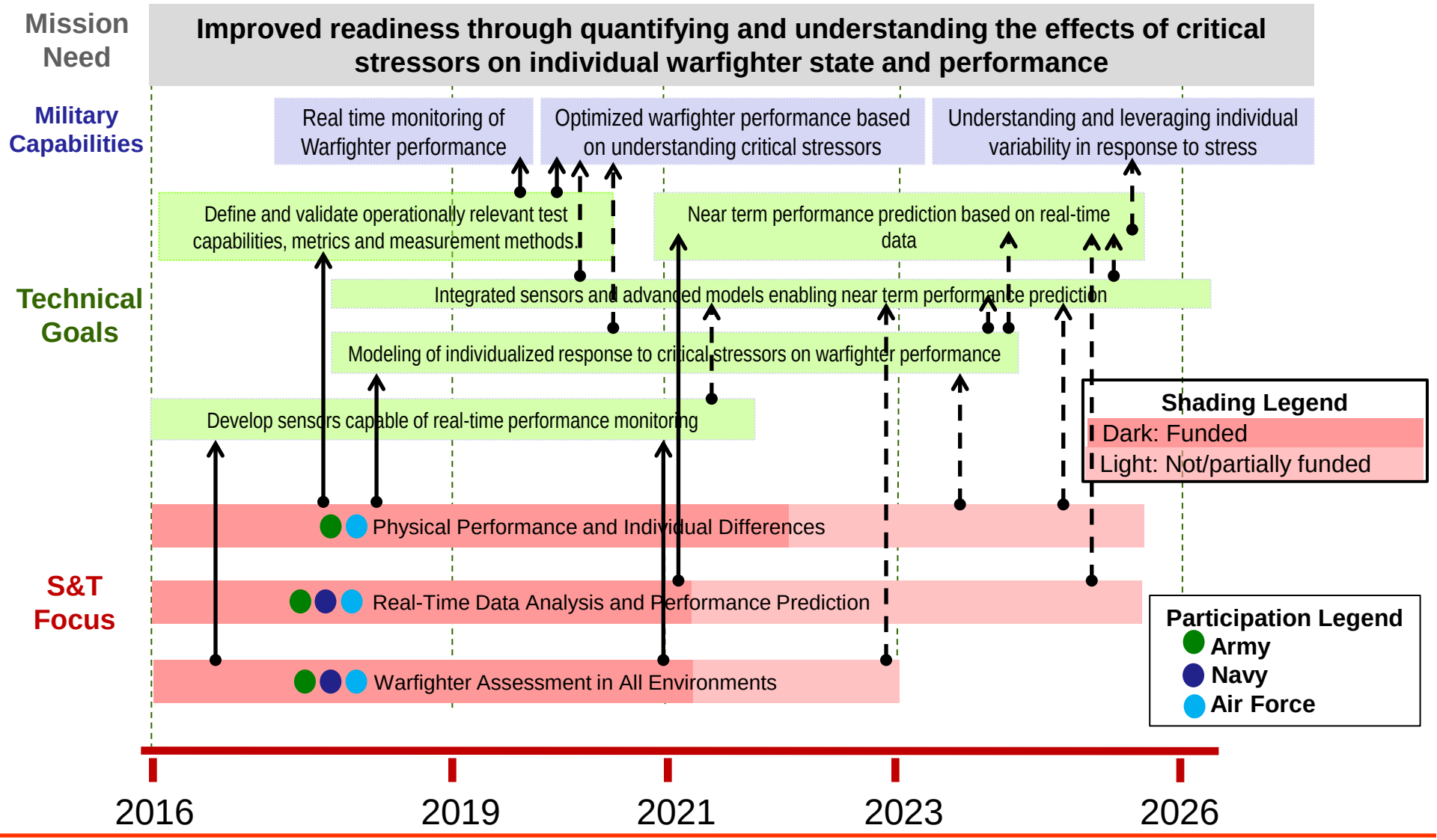
Key Technical Challenges

- Sensors needed that are non-invasive, don't influence performance, and provide meaningful data.
- The underlying mechanisms by which specific stressors influence performance are poorly understood.
- The influence of human variability on the effects of stress on warfighter performance is poorly understood. Some people perform better with stress, others perform worse.
- High fidelity models that predict performance and injury are lacking

Program Overview

- Determinants of hazardous biomechanics
- Omnipresent Real-World Assessment
- Bioeffects: toxic particles, nanomaterials, directed energy exposures

Understanding and Quantifying the Effects of Critical Stressors



Distribution Statement A: Approved for Public Release

Understanding and Quantifying the Effects of Critical Stressors
Program Details

	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Physical Performance and Individual Differences *Understanding the effects of physical stress and of individual variability on the effects of that stress on performance.*	Determinants of hazardous biomechanics						*An understanding the individualized effects of critical stressors on physical performance will enable greater warfighter resilience.*
	Bioeffects:toxic particles, nanomaterials, directed energy exposures						
	Effects of operational environment on pilot toxicology						
	Human Integrated Performance Optimizer						
			Advanced Research focusing on Individual Differences				
Real-Time Data Analysis and Performance Prediction *Developing the ability to predict near and far term performance decrements before they happen.*	High resolution, wearable kinematic sensor and real-time algorithms development →						*Real-Time information on Soldier state and impending performance decrements will provide critical information on Soldier readiness.*
			Real-time IMU feedback to improve Warfighter Performance →				
	Sustainment Technologies for Enhanced Performance of Soldiers (STEPS)						
					Real-Time Bioeffects analysis		
Warfighter Assessment in All Environments *The development of metrics and tools for quantifying Warfighter states in any environment.*	IMU Arrays for Warfighter Kinematic Measurement						*The ability to collect information on Warfighter state in the operational environment. This information can be used to prevent performance decrements.*
			Omnipresent Real-World Soldier Assessment				
					Aerospace Toxicology Human on a Chip →		
					Integrated Sensor Suite Development →		

Success Story: Warrior Web – Physical Augmentation

Operational Challenge

Provide Dismounted Warfighters with physical augmentation tool to reduce effects of heavy load carriage

Problem: Dismounted Warfighters are carrying heavy physical loads, resulting in increased fatigue, which in turn is leading to decreased performance and increased injury.

Objective: DARPA Warrior Web is designed to provide light weight physical augmentation to reduce the effects of heavy physical loads.

Outcome: This is the first time a decrease in metabolic cost has been shown on a military population using physical augmentation in lab and field environments

S&T Accomplishments

- Built and demonstrated component technologies
- Army researchers at have shown that SOME Soldiers exhibit decreased metabolic cost when walking with Warrior Web.
- This is the first time a decrease in metabolic cost has been shown on a military population using physical augmentation

Return on Investment

Readiness

- Decreasing metabolic cost is expected to lead to decreased fatigue and increased physical and cognitive performance.

Warrior Web has been featured in several 'non-industry' media venues, such as NHK Japan's Future Technology mini-series (>10,000,000 viewers), and Science Magazine (Oct 2015)

Thrust 2: Critical Stressor Mitigation Strategies

Delivering the Mission

- Physical augmentation to reduce metabolic cost by up to 25%
- Modeling and Simulation tools capable of predicting physical stress on the Warfighter to within 5%.
- Optimized load configurations and route planning leading to a 10% reduction in metabolic cost and 10% increase in operational performance.

Delivering Capability

- Develop methods of lessening the effects of critical stressors on Warfighter performance
- Understand the underlying mechanisms by which physical augmentation and protection technologies affect performance. Set system requirements.
- Provide the tools (M&S, route planning, etc.) necessary to understand the relationship between new technology, mission requirements and operational effectiveness.

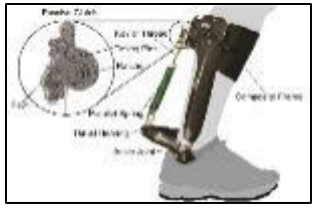
Key Technical Challenges

- Tools to model effects of augmentation on physical performance and injury potential are still in development.
- Route planning tools require high fidelity models of human physiological response to critical stressors.
- Individual variability influences the extent to which physical augmentation can mitigate physical loads

Program Overview

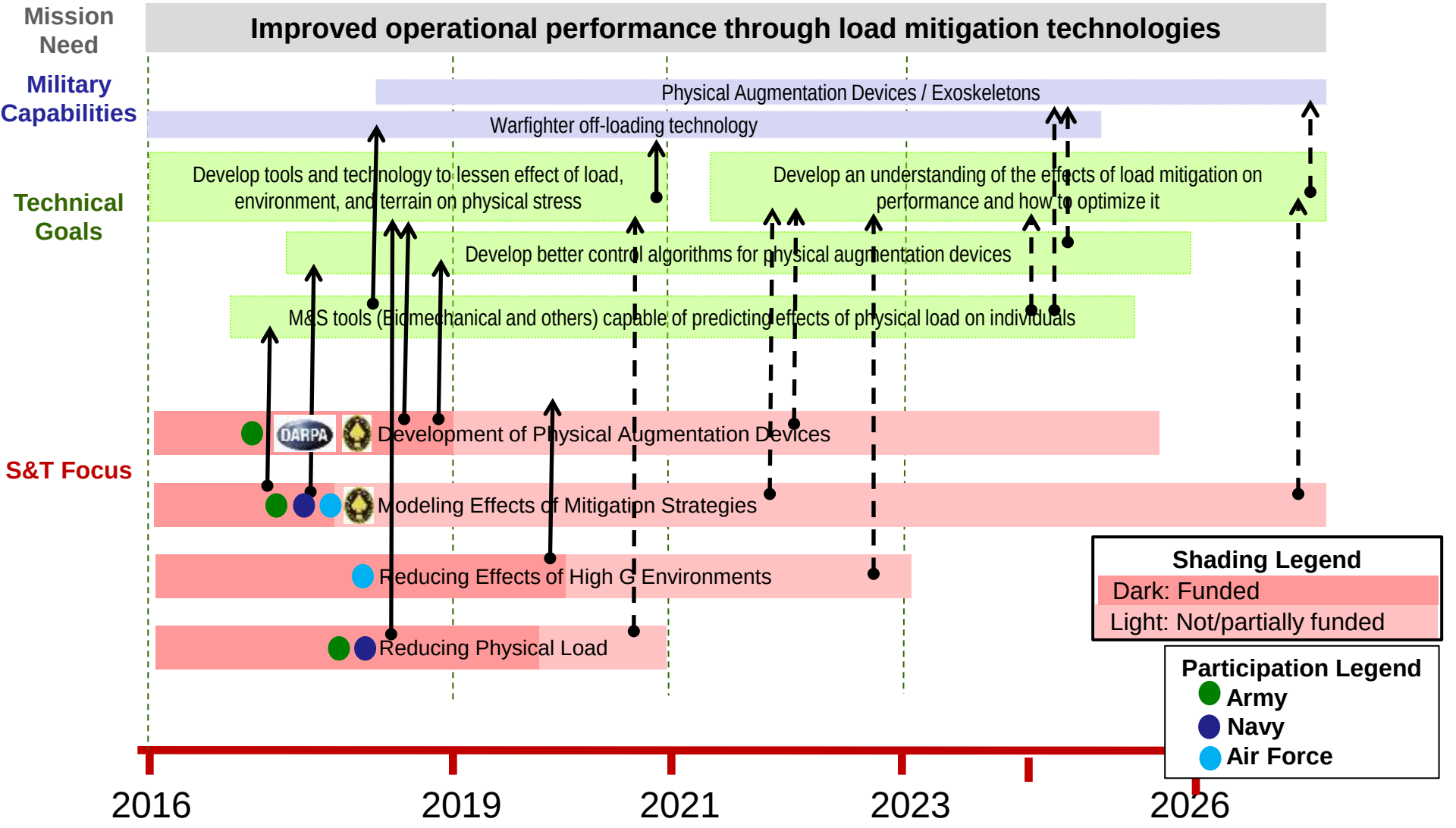
- Lower Extremity motor adaptations to actuation
- Effects of physical augmentation on walking efficiency
- Enhanced Technologies for Optimization of Warfighter Load

Photo property of MIT Prof. Hugh Herr 75 Amherst St., Rm. E14-374L, Cambridge, MA, 02139, (t) 617-258-6574, hherr@media.mit.edu



Wiggin et al. (2014)

Critical Stressor Mitigation Strategies



Critical Stressor Mitigation Strategies
Program Details

	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Development of physical augmentation *Devices designed to lessen the effects of physical load on the Warfighter*	Warrior Web (DARPA)						*Increased endurance, decreased physical fatigue, improved performance.*
	Tactical Assault Light Operator Suit (TALOS)						
	Lower Extremity Adaptations to Joint Actuation						
	Human Body adaptations to physical augmentation						
	The Effects of Training on the Efficacy of a Physical Augmentation Device						
			Advanced control algorithms for enhanced augmentation				
	Ankle Exoskeletons to assist Load Carriage						
Modeling effects of mitigation *M&S aimed at improving augmentation devices and better understanding their effects*	Joint Biomechanical Modeling and Simulation Initiative						*Augmentation devices that are better suited to the user, resulting in increased physical performance, and less cognitive decrement resulting from physical fatigue*
	Enhanced Technologies for Optimization of Warfighter Load						
				3-D Modeling & Spinal Injury Assessment			
	Advanced Human Whole-Body Response Model						
Reducing Effects of High G Environment *Efforts aimed at reducing the effects of high G environments for pilots*					Hypersonic Escape		*Increased pilot performance in high G environments, decreased injury*
					Next Gen Escape Systems Concepts for Pilots		
	Repetitive G-Loading mitigation for Pilots						
Reducing Physical Load *Technology aimed at reducing the physical load (actual weight, 'easier' terrain, etc.) a warfighter needs to traverse.*	NSRDEC Route Planning Tool						*The ability to reduce Warfighter physical load while maintaining capability and performance.*
	Energy Harvesting BackPack						
	Load Carriage / Novel Load Mitigation studies						

Success Story: Jet Fuel Hearing Loss 2015

Operational Challenge

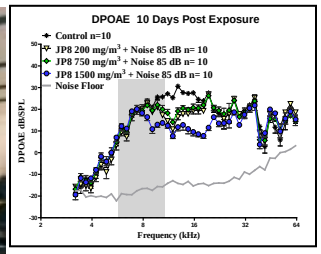
Hearing loss in high noise areas produce life long disability

Problem: The combination of jet fuel and high noise environment can exacerbate hearing loss

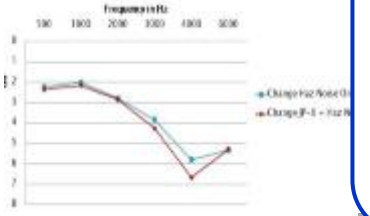
Objective: Expose rats to simulated flight line noise and aerosol exposure to jet fuel and evaluate auditory nerve damage and hearing loss

Outcome: Noise and fuel –increased hearing loss

Retrospective human hear loss in flight line workers – increased hearing loss in fuel handlers on the flight line



Rat hearing loss study



Human retrospective study

S&T Accomplishments

- New finding of auditory nerve damage with fuel exposure
- Transitioned to USAFSAM - hearing database assessment of flight line workers fuel and non-fuel handlers
- Found enhanced hearing loss in fuel handlers
- Transitioned information to flight line workers and assessed personal protection equipment usage reemphasized the importance of proper use of protection equipment

Customers Agile Combat Support. ACC/SG

Return on Investment

Affordability

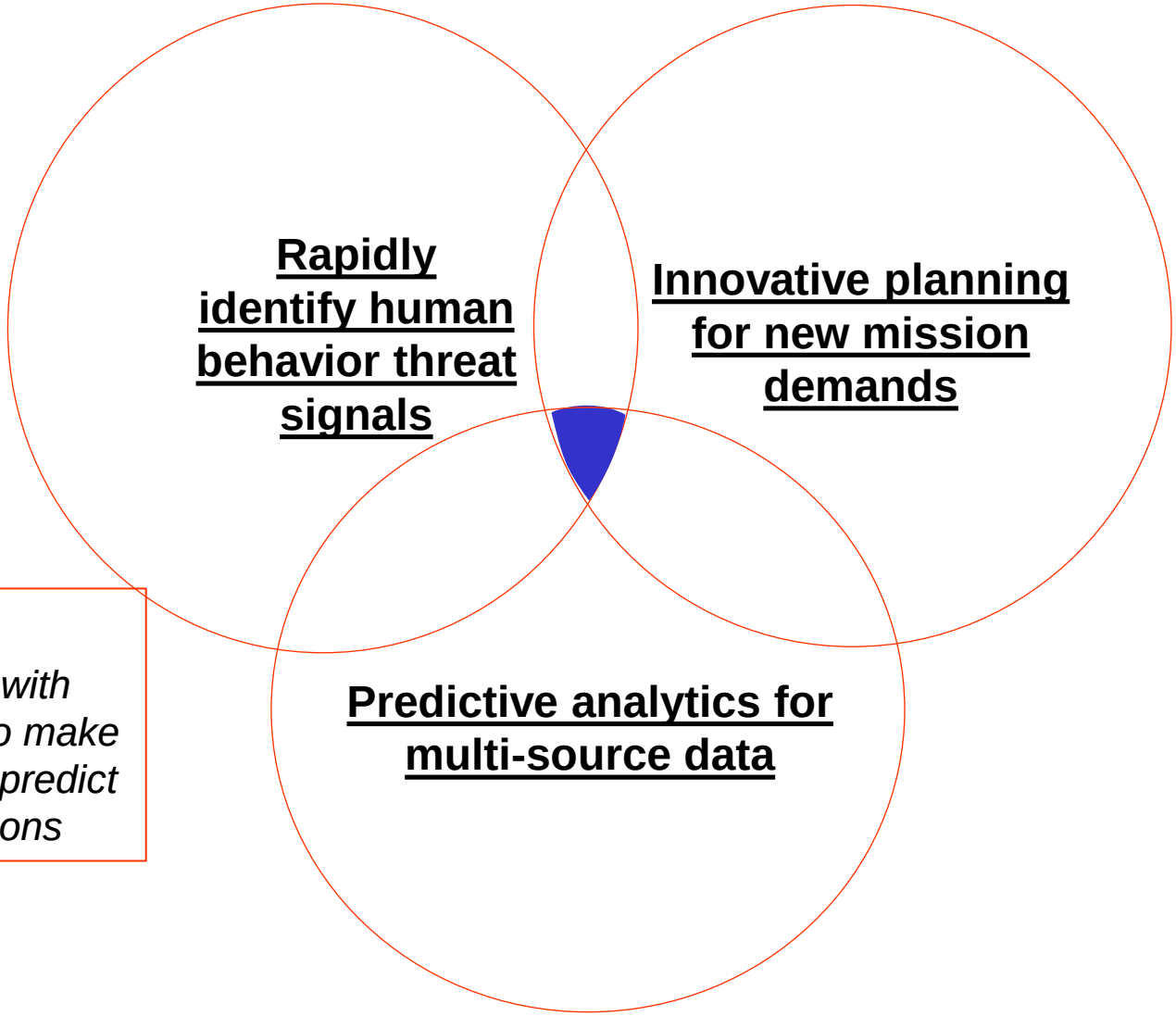
Hearing loss is the number one occupational health issue in the DoD. The cost of treating hearing loss is incurred by both the DoD and VA – more than $1.4 billion in veterans disability payments annually

Readiness

Hearing loss can medically disqualify a military member disqualifying them from both occupations in the DoD or from military service

Human Aspects of Operations in Military Environments

HUMAN SYSTEMS COI SUB-AREA:
Human Aspects of Operations in Military Environments



Vision:

Using effective engagement with the dynamic human terrain to make better courses of action and predict human responses to our actions

Thrust: Exploiting Social Data, Dominating Human Terrain, Effective Engagement

Delivering the Mission

Effectively evaluate/engage social influence groups in the op-environment to understand and exploit support, threats, and vulnerabilities throughout the conflict space. Master the new information environment with capability to exploit new data sources rapidly

- *Defeating novel adversaries in every kind of conflict*

- Extend capabilities for forecast, rapid planning and real-time situation awareness of human activities / behaviors and intent to operators
  - *Forecast models for novel threats and critical events with 48-72 hour timeframes*

Delivering Capability

Predictive, autonomous analytics to forecast and mitigate human threats and events

- Provide real-time situation awareness
  - Engage and defeat new adversaries and tactics
  - Anticipate human crises & mission problems
- Develop data theory and algorithms
  - Develop behavioral models that reveal sociocultural uncertainty and mission risk
- Improve contextual translation & interpretation
  - Discriminating among seized documents

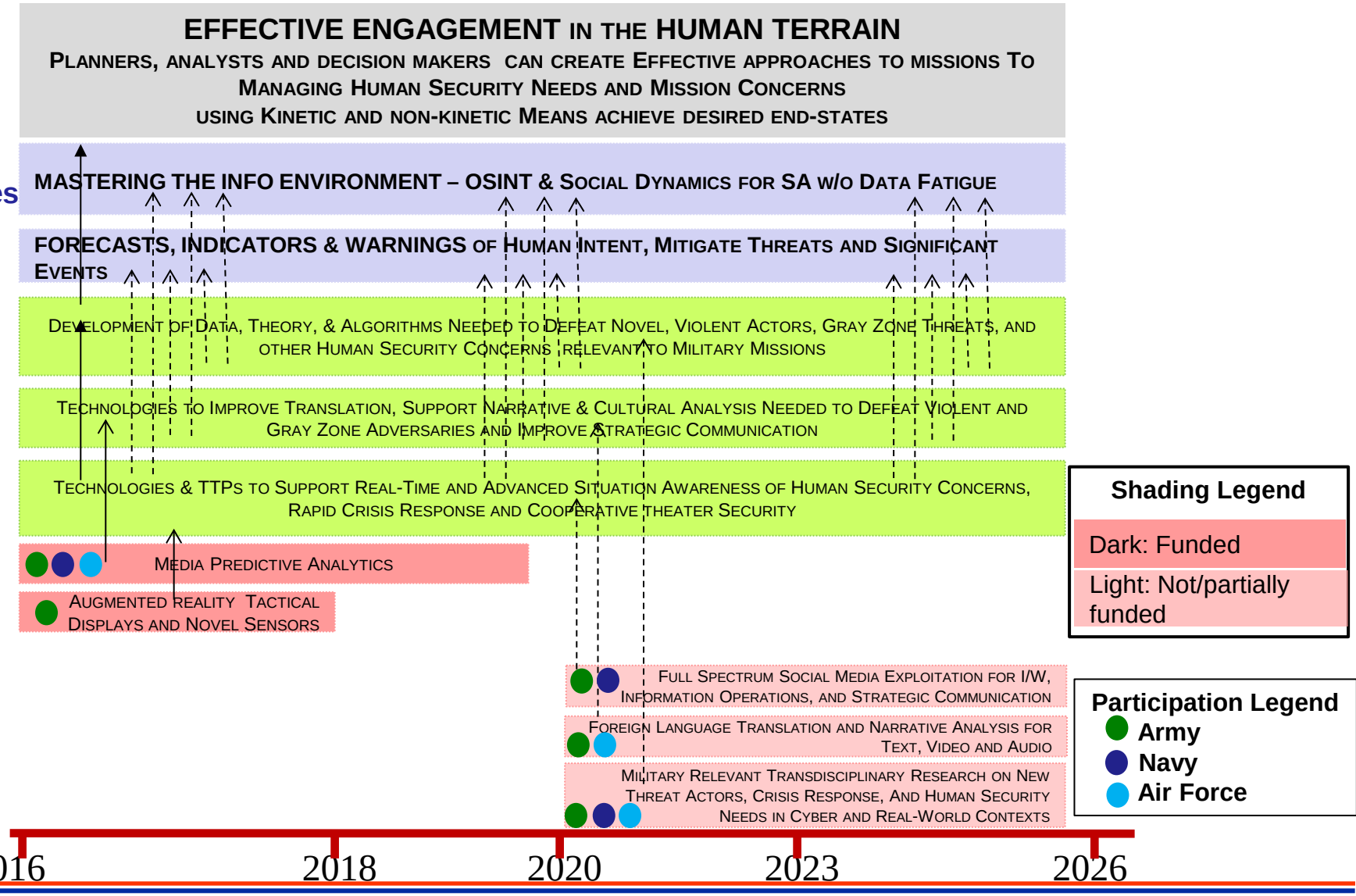
Key Technical Challenges

- Lack advanced modeling and complex algorithms to process new social data streams for actionable information in real-time
- Poorly understand new social dynamics including cyber-social behavior, global reach and new social innovations
- Few well developed counter-measures, TTPs and resources to guide military engagement in the human domain to impact rapidly changing crises
- Goals to drive military capabilities are reliant upon programs that are *not* fully funded and *not* structurally aligned/accountable to long-term military objectives

Program Overview

- *Crisis and Disaster Informatics and Models*
- *Social Network Research on New Threats (Daesh, Novorossiya)*
- *Text Analytics for Context and Event Prediction*
- *Foreign Language Machine Translation for Threat Warnings*
- *COI-coordinated SBIR projects for full spectrum social media analysis*

Human Aspects of Operations In Military Environments



Exploiting Social Data, Dominating Human Terrain, Effective Engagement
Program Details

S&T Focus Areas	Near-term					Mid/ Far-term	Operational Opportunities
	FY 15	FY 16	FY 17	FY 18	FY 19		
Media Predictive Analytics	Content-Based Text & Video Retrieval						Develop real-time understanding of uncertain context with low-cost tools that are easy to train, reduce analyst workload, and inform COA selection/analysis.
	Data to Decision						
	Foreign Language Translation & Narrative Analysis						
	Social Media Exploitation for Intel						
	Social Media Exploitation for HADR						
	Weak Signal Analysis & Social Network Analysis for Threat Forecasting						
Augmented Reality Tactical Displays and Novel Sensors	Social Media Fusion to alert tactical edge Soldiers						Development of devices and tactics to augment tactical edge soldiers with information analysis on-demand in dynamic environments.
	Person of Interest recognition and associated relations						
	Document Exploitation on foreign printed material in field						
	Smart Glass field use for facial recognition						
	Transition to Army labs and Joint Operational Customers (TBD) to include NPS-Maritime Interdiction Ops						

Success Story: Trident Juncture 2015: Social Media Analysis Demonstration for NATO

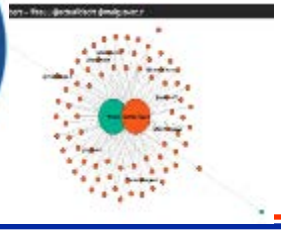
Operational Challenge

Real-Time Support of Strategic Communication During a Live Exercise

Problem: Social media information campaigns during live, massive exercise are brand new to NATO

Objective: Provide real-time understanding of the social media information environment for strategic communication situation awareness

Outcome: Recognition and invitation to assist NATO to develop a Digital Working Group in 2016, future engagements to be discussed for 2017



S&T Accomplishments

- Rapid training (>3 hours) of personnel accomplished
- Curated over 2M relevant tweets, including information attacks (trolling) and other conflicts in the information space, including 6 months of baseline analysis
- Curated and analyzed over 20K tweets and 700 Instagrams during the exercise.

Customers included NATO HQ personnel, the NATO Military Information Center staffers, JFC Brunnsum public affairs, EUCOM, and other VIPs from SHAPE HQ, DSTL and HQ ARRC.

Return on Investment

Affordability

Capabilities demonstrated are 1/4th the cost of COTs tools, with 50% less manning required than COTS to achieve equivalent situation awareness|

According to Department of State users.

NATO funded the travel and accommodations for USG participants (Thank to JFC Brunsumm HQ)

Readiness

Army and Navy have several technologies that are ready for such technical demonstrations (shown at TJ15 as a joint effort)

NATO, NATO Allied Command Transformation and constituent NATO partner nations are very interested in closer cooperation in this kind of research and development.

Success Story: SCRAAWL: Joint Army/Navy Social Media Analysis and Models

Operational Challenge

Provide real-time situation awareness and automated analytics of social media sources with low manning, at affordable cost

Problem: Military and USG responders to crisis need the rapid SA that social media can provide, but must be able to rapidly see whole patterns of data flow and critical pieces of data that actionable.

Objective: Rapid SA from social media with low manning, with ability to discern actionable information readily,

Outcome: Control of strategic narratives, capability to discern and counter competitive and hostile messaging, "know what the crowd knows" about changing situations on the ground in real time.

S&T Accomplishments

- Real-time monitoring and 30-day backlist of breaking news and topics
- Automatic identification of viral information and rumor
- Automatic identification of suspected false accounts.
- Automatic identification of viral photos and videos
  - *Transitioned to SOCOM Open Source Environment and Combat Zone Tool Kit for multiple commands*

Return on Investment

Affordability

- 1/4th the price of comparable systems
- Low training requirements

Readiness

- New capabilities are being added to existing commercial system, in daily operational use. Joint funded by Army and Navy.

Thank You